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Reliability Test for Fetal Fat Programme

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Introduction: The ability to detect fetal fat is potentially important in assessing fetuses in compromised pregnancies related, for instance, to intrauterine growth restriction (small fetus often associated with inadequate placental function) or macrosomia (abnormally large fetus associated with maternal diabetes). Both of these conditions are associated with poor pregnancy outcome and long-term risks to the health of the offspring [1,2]. Hence, we developed a scanning and analysis protocol for estimating fetal fat composition. One of the problems with estimating fetal fat is to determine where in the body it should be measured. We have considered two approaches: measuring fetal fat across the abdomen and measuring fetal fat across the whole body. Since the analysis required some operator input we have also analyzed the interobserver and intraobserver repeatability of the results. This abstract describes the protocol and initial efforts to test its reliability.

Methods: Scanning: Following ethics committee approval, 10 healthy pregnant women from Queen's Medical Centre Nottingham were recruited and gave informed consent to participate in the study. Pregnant women underwent a single scanning session between 38 and 40 weeks gestation since the subcutaneous fetus fat was only visible on the MRI scans after 30 weeks gestation. They were scanned using 1.5 T Philips Achieva MRI scanner using, depending on the woman's size, either 5-element SENSE cardiac coil or 4-element SENSE torso coil. Women lay on their right side in the decubitus position to avoid vena cava compression; all these scans were conducted with a specific absorption rate of <2.0 W/kg. The sequence used to study fetal fat was a breath-held, multi-slice, water suppressed fast field echo (FFE) sequence acquired transverse to the fetus. The first *ABDO* sequence acquired 5 slice over the fetal abdomen (below lungs to rump) in 5.1 seconds (TR = 62 ms, TE = 4.6ms, 1.88x1.86x6.00 mm³, slice gap = 0mm and FOV = 402mm). The second *TOTAL* sequence acquired 12 slices encompassing the whole fetus in 12.4 seconds (TR = 147ms, TE = 4.6ms, 1.88x1.86x6.00 mm³, slice gap = 20mm and FOV = 402mm). In both cases the regularly spaced slices were positioned randomly with respect to the fetus to allow an unbiased estimate of the fat in the volume of interest.

Analysis: The resulting images clearly show fetal and maternal fat (and little else) but the fetal fat-distribution is too complex to allow for reliable manual segmentation. Instead we developed a semi-automated approach based on image thresholding. First, the images were loaded into GIMP (GNU Image Manipulation Program) where the observer drew an approximate freehand mask around the fetus to discard maternal fat. The mask and images were then loaded into MATLAB to compute the intensity histogram of both scans within the masked region. We observed that those histograms were often bimodal with one peak for background noise and a second one for fat voxels. Therefore the histogram was differentiated with respect to pixel intensity to determine the threshold separating fat and background noise signals automatically.

Validation and precision: Six observers measured the fetal fat twice each for the *ABDO* data set to allow inter-observer and intra-observer reliability to be assessed. One observer measured both the *TOTAL* and *ABDO* data sets in 6 subjects to determine whether the *ABDO* data set adequately predicted total fetal fat (assumed to be given by the *TOTAL* data set). To validate the procedure, a phantom was also produced containing 250ml saline and 150ml goose fat placed in a glove that was tied tightly excluding air bubbles before being placed in a plastic box containing 1600ml of saline.

Results The program measured the fat volume of the phantom to be 144 ml. Considering the data from the 10 subjects the intra-observer limit of agreement was 10% and the interobserver limit of agreement was 7%. The *ABDO* and *TOTAL* data sets showed good correlation ($r^2=0.87$) (the outlier point actually being affected by motion).

Discussion: Fetal fat can be visualised and quantified with MRI. There no gold standard against which to test these results, but the spread between fetuses suggests the technique will have good sensitivity and the repeatability analysis show that the technique has good reliability. Volumetric assessment is challenging since it is not feasible to image every slice in a reasonable imaging time, so the fetal fat must be sampled from a set of images taken from the whole set covering the fetus. The question then is how to select the slices. We considered two options, sampling over the abdomen (*ABDO* - generally the region of interest in adults), or sampling over the whole fetus (*TOTAL*). The difficulty with the *ABDO* protocol is that the results will depend on slice positioning (as this will determine the region of the fetus sampled). The problem with the *TOTAL* protocol is that it requires the mother to hold her breath for a long time, it takes a long time to analyse the data, and image quality can drop at the top and bottom slices if they fall at the edge of the coil and shim volume. This work showed that both results of both techniques are well correlated suggesting that *ABDO* protocol will provide an adequate assessment of abnormal fetal growth. Future work will consider correlation of fetal fat with fetal birth weight and scan/rescan repeatability.

Reference: [1] S.A. Walkinshaw. (2005), Pregnancy in women with pre-existing diabetes: Management issues. *Seminars in Fetal and Neonatal Medicine* **10** 307-315. [2] M.S. Kramer, R.W. Platt, S.W. Wen, K.S. Joseph, A. Allen, M. Abrahamowicz, B. Blondel, G. Breart, and S. for the Fetal/Infant Health Study Group of the Canadian Perinatal Surveillance. (2001), A New and Improved Population-Based Canadian Reference for Birth Weight for Gestational Age. *Pediatrics* **108** e35.

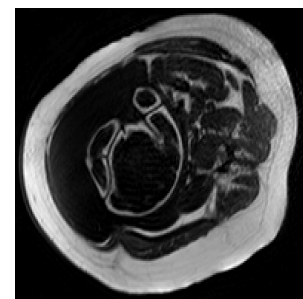


Figure 1: Fat only image of a transverse plane through the fetal thorax (arms visible).

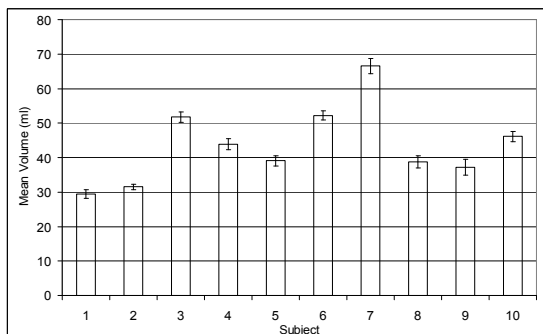


Figure 2: Reliability of fetal fat estimation from the *ABDO* scan for 10 different subjects tested by 6 different observers.

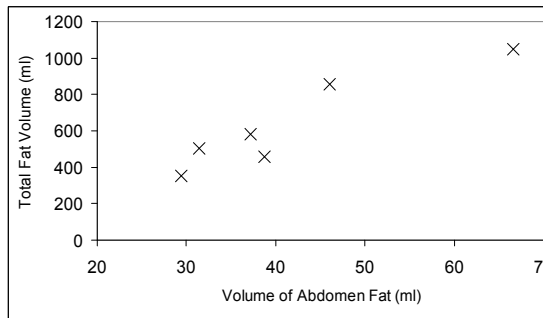


Figure 3: Comparison of *ABDO* and *TOTAL* volume estimates.